理学博士赤祖父俊一君の「磁気圏擾乱の研究」に対する授賞審査要旨

一、概　要

太陽から常時超音速で放出されている高温の電離気体流は太陽風と呼ばれているが、この太陽風は地球磁場の影響を受けて、地球の半径の約一〇倍以内の領域には侵入することが出来ない。この領域が磁気圏であり、それは彗星の尾のような形をして、太陽と反対側に長くのびている。この太陽風と地球磁場との相互作用は自然の巨大な電磁流体発電作用となって現われる。すなわち電離気体流である太陽風が地球磁場を横切って運動するため起電力が発生し、それによって極地の超高層大気中に生ずる放電現象がオーロラである。

太陽風は太陽活動の影響を受けて、常に非定常な状態にあり、衝撃波、磁場の不連続面、電磁流体波などの変動を伴っている。それに呼応して磁気圏の内部にも種々の擾乱が生ずる。赤祖父君は、それらの一つであるオーロラの変動、すなわちオーロラ嵐、の研究を基礎として、磁気圏サブストームという概念を確立した。これは最近の磁気圏研究上の指導的概念であって、同君はこれによって、極地超高層大気擾乱、極地磁気嵐、電離層嵐等の諸現象を綜合的に体系づけることに成功した。同君はさらに人工衛星による磁気圏観測を解析することにより、磁気圏サブストームの物理過程を解明してきた。

二、オーロラ嵐の研究

国際地球観測年（一九五七年）中には、高緯度地方の百カ所以上にのぼる地点において全天カメラによるオーロラの同時観測が行われたが、それによって得られた百万枚近くの写真の解析を基礎として、赤祖父君は極地全体にわたって現われるオーロラの動静を研究した。そして従来断片的に研究されていたオーロラをグローバルに捉えることに成功し、オーロラ形態学上に大きな進歩をもたらした。それによると、オーロラ嵐の発達過程には規則性があって、静相、フレアー相、回復相の段階がある（三八、四七）。磁極点をとりまくオーロラ・オーバルに沿ってオーロラ・カーテン全体が静かに横たわっている時が静相であるが、このカーテンは真夜中の部分で急速に明るさを増し、それと共にその静けさが破られる。カーテンはぐるぐると烈しく巻きながら北の空（北半球では）に移動し、それに伴ってカーテンに大きな波が生じ、その波はオーロラ・オーバルに沿って西の空に伝播して行く。この段階がフレアー相である。やがてカーテンは緯度七五度付近まで達すると静止し、その後静かに南の空に移動をはじめる。この段階が回復相で、移動をはじめてから約二時間後にもとの静かな状態―静相―にもどる。オーロラは上のような変化を、正しく周期的にではないにしても、割合に規則正しく繰り返す。赤祖父君のこの研究は一九六四年に発表されたが、その後一九七四年に人工衛星によるオーロラの写真観測によって確認された（一八三）。

三、磁気圏サブストーム

このオーロラ嵐の発達過程は、磁気圏内の電磁場の諸変動に一連の脈絡があることを意味するものであり、ここでオーロラ嵐の概念を一般化した磁気圏サブストームという概念がブライスによって導入された。赤祖父君は、磁気圏

サブストームは、太陽風と磁気圏との相互作用に基づく起電力によって磁気圏に貯えられた磁場のエネルギーが、突発的に荷電粒子エネルギーに変換される現象であるとした。その際そのエネルギーの一部は放電作用によって極地超高層大気中に放出されてオーロラ嵐となる。さらに赤祖父君は極地磁気嵐、電離層嵐、X線嵐、超低周波電波嵐、地磁気脈動嵐などの一連の極地超高層大気の擾乱もオーロラ嵐と同様に磁気圏サブストームによって統一的に体系づけられることを示した。同君はこれらの研究を綜合して Polar and Magnetospheric Substorms (D. Reidel Pub. Co., 1968) を著したが、これは磁気圏研究者の重要な参考書になっている。

この磁気圏サブストームの概念は人工衛星が威力を発揮する以前に提出されたものであるが、その後人工衛星によって磁気圏内の磁場、電場、荷電粒子の性質などを直接に測定することが可能となり、これは磁気圏サブストームの研究上有力な手段となってきた。赤祖父君は人工衛星観測の解析についても指導的な役割を演じ、オーロラ嵐の規則性に対応して、磁気圏内の磁場、電場および荷電粒子にも規則的な変動があることを示した。これによって磁気圏サブストームは観測によって裏付けられることになった。

四、地磁気嵐

磁気圏サブストーム時に生ずる極地磁気嵐は、一九六〇年頃まではグローバルな規模で起る地磁気嵐に伴う付属的現象と考えられてきた。しかし赤祖父君と S. Chapman 教授はこれと全く逆に、極地磁気嵐、磁気圏サブストームこそ地磁気嵐を引き起す要素であることを示した(三二)。すなわち磁気圏サブストームが頻繁に発生するとき、加速された高エネルギー荷電粒子（特に陽子）がバン・アレン帯内に注入されることによって、地球をとりまく赤道環電

流系が形成される。この電流系は地球のまわりを西向きに流れる傾向があるので、それによる磁場は地球の磁場の強さを減少させ、それによって、いわゆる地磁気嵐の主相が生ずることを明らかにした。赤祖父君はさらに、このバン・アレン帯内に注入され捕獲された荷電粒子群の運動を研究し、赤道環電流の分布およびそれに基づく磁場の分布を数値計算によって求めた(二八)。この計算結果が正しかったことは人工衛星による観測によって確められた。またこれに関連して、赤道環電流は古くから考えられて来たような完全な環状電流ではなく、その一部が欠除していることを、同君は地磁気嵐の磁場の解析から推定したが、このこともその後人工衛星による観測によって確められた。

五、磁気圏サブストームの物理機構

赤祖父君の最近の研究は磁気圏サブストームの物理機構の解明に向けられている。太陽風、磁気圏相互作用は太陽風荷電粒子の運動エネルギーを磁気圏の磁場のエネルギーに変換し、磁気圏尾に貯える。同君は人工衛星から写されたオーロラの写真と、他の人工衛星による惑星空間磁場の観測とを比較解析することによって、オーロラ・オーバルの大きさが磁気圏尾に貯えられたエネルギーに比例することを見出した(一九二)。さらに、オーロラ・オーバルが変動するという事は、磁気圏の真昼側での「開いた磁束」の生成率と真夜側での「閉じた磁束」の生成率との不均衡によるものであり、磁気圏尾に磁場のエネルギーが貯えられつつある時は、開いた磁束の生成率が閉じた磁束の生成率より大きく、この不均衡は磁気圏サブストームという突発的な過程の発生によって解消させられる事を示した(二〇八)。すなわちまず磁気圏尾をシート状に満たしているプラズマ・シートと呼ばれる荷電粒子の層が突然不安定になり、地球に向って流れ出し、収縮してしまい、収縮に伴って磁場のエネルギーが荷電粒子のエネルギーに変換される

こと、すなわち磁気圏サブストームが発生することを示した。同君はこれらの研究を、Physics of Magnetospheric Substorms (D. Reidel Pub. Co., 1976) と題する著書にまとめた。

赤祖父君は、「荷電粒子と地球磁場の相互作用についての重要な研究、特に極および磁気圏サブストームの解明についての基本的な貢献」に対し、一九七六年一月に英国王立天文学会よりチャップマン・メダルを受けた。

これを要するに、赤祖父君の磁気圏擾乱に関する一連の研究は磁気圏サブストームを中核として磁気圏で行われている物理過程の解明に重要な貢献をなしたものといえる。

主要な著書および論文目録

イ　著　書

一、S.-I. Akasofu and S. Chapman: Solar-Terrestrial Physics. Oxford Uuiversity Press, 1972.
この本は太陽からくる電磁波および粒子によって、地球の高層大気中に引き起される諸現象について述べたもので、現在超高層大気物理学の標準教科書となっている。

二、S.-I. Akasofu, B. Fogle, and B. Haurwitz: Sydney Chapman, Eighty. 米国大気研究センターとコロラド大学出版部、一九六八年

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